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LABORATORY DESIGN FOR STUDY OF INFECTIOUS DISEASE

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ABSTRACT

Some fundamental criteria and typical layout sketches are presented to assist those interested in designing new infectious-disease laboratories or in the conversion of existing facilities. Some typical safety equipment desirable in these laboratories is described. The basic concepts presented, and the equipment recommended, have been proved in actual practice and found to be of value in preventing laboratory infections.

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I. INTRODUCTION

The study of microorganisms highly infectious to man is conducted in many laboratories with little mechanical protection for the experimenters or for persons, such as dishwashers and clerical assistants, who are more or less remotely connected with the project. In fact, in many infectious disease laboratories, visitors, students, and other transients have free access to the laboratories. This has sometimes led to infection of such persons.[1-3]*

Although acquiring laboratory infection has often been viewed in the past as "part of the job," legal and moral considerations currently emphasize the responsibility of the laboratory director in protecting those associated directly and indirectly with the research. For several reasons, therefore, some laboratories are reluctant to work with organisms such as Coxiella burnetii, Coccidioides immitis, and Russian spring-summer encephalitis virus, or to undertake microbiological experiments which, in themselves, are hazardous even though the organisms are of moderate infectivity under ordinary conditions (e.g., respiratory challenge of animals with Bacillus anthracis). Inasmuch as the respiratory route is often the normal means of infection, this reluctance is a handicap to the advancement of medical research. Accordingly, it appears appropriate to outline some of the fundamental concepts for the design of infectious disease laboratories and accompanying equipment that have been found at this installation to work effectively in reducing or preventing laboratory infections. Also, it seems pertinent to present typical designs for small infectious units that may be particularly applicable for schools, universities, or small research institutions.

Previous publications describing the frequency of laboratory infections[4,5] and the hazards of certain bacteriological[6] and viral[7] techniques will serve as adequate justification for certain recommended design features. Justification can also be found in the original publications for the use of certain laboratory equipment designed to reduce microbiological hazards. Other references pertaining to microbiological safety, which appeared after the review by Wedum,[8] have been included for the convenience of the reader. It is suggested that the information in this report be used to supplement standard construction guides and specifications where applicable. The features described in this report are for the purpose of limiting or controlling direct or indirect contact with infectious agents. It is intended (a) to consider the minimum design features and equipment necessary for infectious disease units; and (b) to present typical designs for a small infectious disease unit. The descriptive terms used throughout the text have been purposely selected to be most appreciated by both the microbiologist and the design engineer.

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* See Literature Cited.

II. DESIGN FEATURES OF INFECTIOUS DISEASE UNITS

The design features considered essential for infectious disease units are categorically separated and described below.

A. LOCATION OF INFECTIOUS UNIT

If feasible, the unit should consist of a separate building not used for classrooms or noninfectious work, and removed from public gathering places. However, if it is located in a large building used for other purposes, a site in a remote or noncongested part of the building should be selected. Conversion of existing laboratories is recommended, but the space available and its suitability for the proposed operation must be carefully considered.

B. TYPES OF ROOMS REQUIRED

The type of room depends somewhat on the type of operation, the number of laboratory personnel involved, and the subsidiary facilities available in adjoining areas. For this report, it will be assumed that the following rooms will be required:

(a) Locker and dressing room for storing street clothes (clean change),
(b) Shower room with space for removing laboratory clothing (contaminated change),
(c) Laboratory room,
(d) Animal room,
(e) Preparation room,
(f) Storage room, and
(g) Air locks.

Other rooms, such as those for holding laboratory animals before use, may be necessary if not available outside the unit. More than one laboratory or animal room may be required. Our experience is that the need for animal room space is often underestimated. The first three rooms listed above are essential. Storage and preparation rooms may be omitted from the unit if available elsewhere.

C. FLOORS, CEILINGS, AND WALLS

Floors, ceilings, and walls in infectious disease laboratories should have a final surface free of cracks or crevices and capable of withstanding frequent washes with decontaminating solutions. Suspended ceilings, except in corridors, are not recommended. The corrosive characteristics of the

decontaminating solutions to be used should be thoroughly investigated; corrosive effects on metals, rubber, paint, or wood do not always correspond to tissue toxicity.

The construction of walls, ceilings, and floors should not allow leakage of liquids into adjoining rooms or rooms below. When concrete slab floors are involved, it is important that wall curbs be poured integral with the floor to prevent liquid leakage.

The walls and ceilings of existing structures may require the application of pressure-sensitive tape to seal joints between panels. If new construction is involved, concrete floors and brick or mortar walls may be finished with Keene cement plaster finish. Some of the newer types of porcelain enamel panels may be suitable, but the construction must provide air-tight walls and ceilings, except for interior door openings. The ceiling construction, particularly, should be tight enough to provide an effective barrier between the laboratory rooms and the "clean" rooms or "clean" attic above. As an example, it is inadvisable to have light fixtures recessed into the room ceiling for servicing from the attic above, because this obviously increases the difficulty of obtaining a good seal between the infectious room and the "clean" attic.

Paints for walls and ceilings should be resistant to the chemical disinfectants to be used. A light-colored gloss enamel protective coating is recommended, such as the vinyl base Tygon "TP" series[a] or the epoxy-resin-base Nu Pon system.[b] Concrete floors may be painted, but if left unpainted, the surface should be treated with a suitable sealing compound, such as "Lapidolith,"[c] to harden the surface and reduce the "rub-off" of concrete dust.

D. WINDOWS AND DOORS

In designing new construction, nonopening windows glazed with Thermopane should be specified. All caulking and sealing materials must withstand exposure to liquid disinfectants. Synthetic rubber compounds, such as DEL seal[d] or Weatherban Sealer[e] are useful for this purpose. In existing buildings, windows should be sealed in a closed position.

All doors should have automatic door-closing devices. Doors leading into contaminated rooms should be provided with glass viewing panels and clear plastic speaking diaphragms[f] about six inches square. The diaphragms should be easily replaceable and may need protection by wire screening.

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a. US Stoneware, Dayton, Ohio.
b. The Glidden Co., Reading, Pennsylvania.
c. L. Sonneborn Sons, Inc., New York City.
d. David E. Long Corp., New York City.
e. Minnesota Mining and Manufacturing Co., Detroit, Michigan.
f. Saran Film No. 517, 200 Gauge, Dow Chemical Company, Midland, Michigan.

This means of visual and oral communication will aid in limiting traffic into contaminated rooms. Doors through which laboratory carts are pushed should be provided with a four-foot kick plate of 16-gauge metal sheeting.

E. VENTILATION AND AIR TREATMENT

1. Room Ventilation

Air supply and air exhaust systems are essential to maintain proper air flows and pressures within the unit. Air is supplied at a rate to provide about ten changes of air per hour in each room, except where more air is needed because of the heat load. A slight negative pressure can be created by adjusting the relative amount of air supplied and withdrawn from each room. Ideally, it is desirable to maintain the entire infectious unit at a reduced pressure in relation to the outside or to the adjoining noninfectious areas.

Within the unit, increasing degrees of reduced pressure can be provided; the more hazardous rooms should be negative in relation to less hazardous rooms. In this arrangement, the direction of air flow will always be in the direction of the most hazardous room. In converting existing laboratories, inexpensive air exhaust blowers may be used without an air supply system. If exhaust fume hoods are provided over autoclaves or sterilizing ovens, air may be exhausted through the duct. The degree of negative air pressure necessary to maintain proper air balance is in the order of 0.05 to 0.15 inch of water. Supply air must be provided when air is being withdrawn from the room by ventilated cabinets (Section III). A damper arrangement should restrict supply air when ventilated cabinets are not in operation.

Supply air for the infectious unit may need coarse filtration (bacterial filtration efficiency of 20 to 50 per cent) if there is a significant load of pollen, mold, nonspecific bacteria, smoke, or dust in the outside air.

Proper ventilation and the use of bacterial filters will isolate areas of different levels of hazard. A system in which air is used once, filtered, and discharged to the outside is preferable; however, in the absence of unusual hazards, recirculating air systems may be used if the air is processed through an efficient filter in the exhaust duct as it leaves each room. The building exhaust should be located so that air will not be reintroduced into the same building through an open window or other air inlet.

Air conditioning is desirable in laboratory areas so that the air balance will not be disturbed by the opening of doors or windows during hot weather. From an engineering viewpoint, building heat loads are related to ventilation and must be carefully considered. It has been our experience that heat from autoclaves, heat ovens, water baths, gas burners, and such

equipment is often underestimated in building designs. Air exhaust hoods over autoclaves, particularly autoclaves extending into animal rooms, are suggested.

2. Cabinet Ventilation

Air exhaust blowers for ventilated cabinets should provide a minimum air flow of 50 linear feet per minute through all open spaces in the presence of filter resistance. To maintain this standard during varying conditions and increasing filter resistance, it is wise to add a 20 per cent safety factor. For instance, an air exhaust fan for a cabinet 72 inches long with the 10-inch glove panel removed[8] will need to exhaust a theoretical minimum air volume of 250 cubic feet per minute (cfm) against an initial filter resistance of approximately 1.0 inch of water created by two layers of 50 FG spun glass;* the working installation should provide 300 cfm against a resistance of 3.0 inches of water. If air is incinerated, resistance to air flow is decreased, but a blower resistant to high temperatures must be used, because of the temperature of the air that passes through the blower. Blowers should always be positioned on the downstream side of the filter or incinerator.

3. Treatment of Exhaust Air

A variety of filter media is available for removing microorganisms from exhaust air. Bacterial filtration efficiencies of 90 to 99 per cent are acceptable for the general building exhaust, provided that primary filtration or incineration of air is used at the site of particularly hazardous operations. Generally, filters using pads of spun glass having an efficiency of 99 per cent or greater are recommended.[9] Inspection of the filter media, clamping the filter into the filter frame, and the proper seating of the frame in the plenum chamber are important to prevent leakage of unfiltered air.

Before periodic changing of used filter media, it is usually desirable to house all filters in their frames in plenum chambers equipped with facilities for decontamination. When infectious microorganisms have been used, the plenums and filters must be decontaminated, because the handling of dust-laden filters with entrapped pathogens is hazardous. Dry heat and steam formaldehyde treatments are, at present, the most effective means of decontaminating filters.[9,10] Electrically heated air at 400°F will sterilize spun-glass filters in a two-hour period. Sterilization with steam formaldehyde is described later in this report.

In our experience, electronic precipitation for the treatment of exhaust air, although effective, has required considerable attention with consequent high maintenance costs. Regular servicing is necessary to obtain rated filtration efficiencies. Continuous oil-screen filters with 50 per cent filtration efficiency are useful as prefilters in some situations.

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* American Air Filter Co., Louisville, Kentucky.

Incineration has the disadvantage of greater expense of installation and operation, except for comparatively small volumes of air such as 75 to 90 cfm. Tests of a 75-cfm electric incinerator[11] have shown that air laden with bacterial spores can be sterilized at 575°F when the exposure time is three seconds. Such an incinerator, preceded by a filter, is advised for treatment of air from ventilated cabinets in which: (a) aerosols are deliberately created for exposure of animals; (b) fluid or dry-particle infectious aerosols of considerable quantity are created, as in extensive use of a Waring Blendor, preparing, grinding, or weighing dry bacteria; or (c) air is released from fermentors or production containers.

Large oil-fired or gas-fired incinerators are feasible when large volumes of air containing highly infectious microorganisms must be handled, but these are not recommended except under unusual circumstances. The use of a 1200-cfm gas-fired incinerator for sterilizing exhaust air from an isolation area consisting of four laboratory rooms has been reported.[12] Figure 1 shows the typical air flow pattern for an infectious disease building.

4. Fans and Blowers

When calculating the capacity of the building exhaust blower, the resistance created by the air filters should be considered. Building exhaust and supply fans should be electrically interlocked so that the supply blower will shut off if the exhaust blower fails, but not the reverse. This is necessary to prevent pressurizing the infectious areas if the exhaust fan fails.

All procedures and operations involving highly infectious materials should be conducted in ventilated cabinets. Separate blowers remove air from these cabinets, and after primary filtration, discharge it into the building exhaust ducts. The exhaust serving ventilated cabinets should be independent of the building exhaust and should continue to operate if the building exhaust fails.

F. LABORATORY SERVICE EQUIPMENT

Laboratory service lines supplying compressed air require no treatment unless air is compressed in an infectious area. In this case, the air may be passed through a bacterial filter before compression.

If the vacuum pump is located outside of the infectious laboratory, a suitable bacterial filter should be installed where the vacuum pipe leaves the room. Pumps and motors supplying vacuum, compressed air, or refrigerant should be located outside the infectious unit (preferably in an adjoining utility room). Compressed air for ventilated suits or personnel head hoods should be drawn from air free of objectionable fumes and odors,

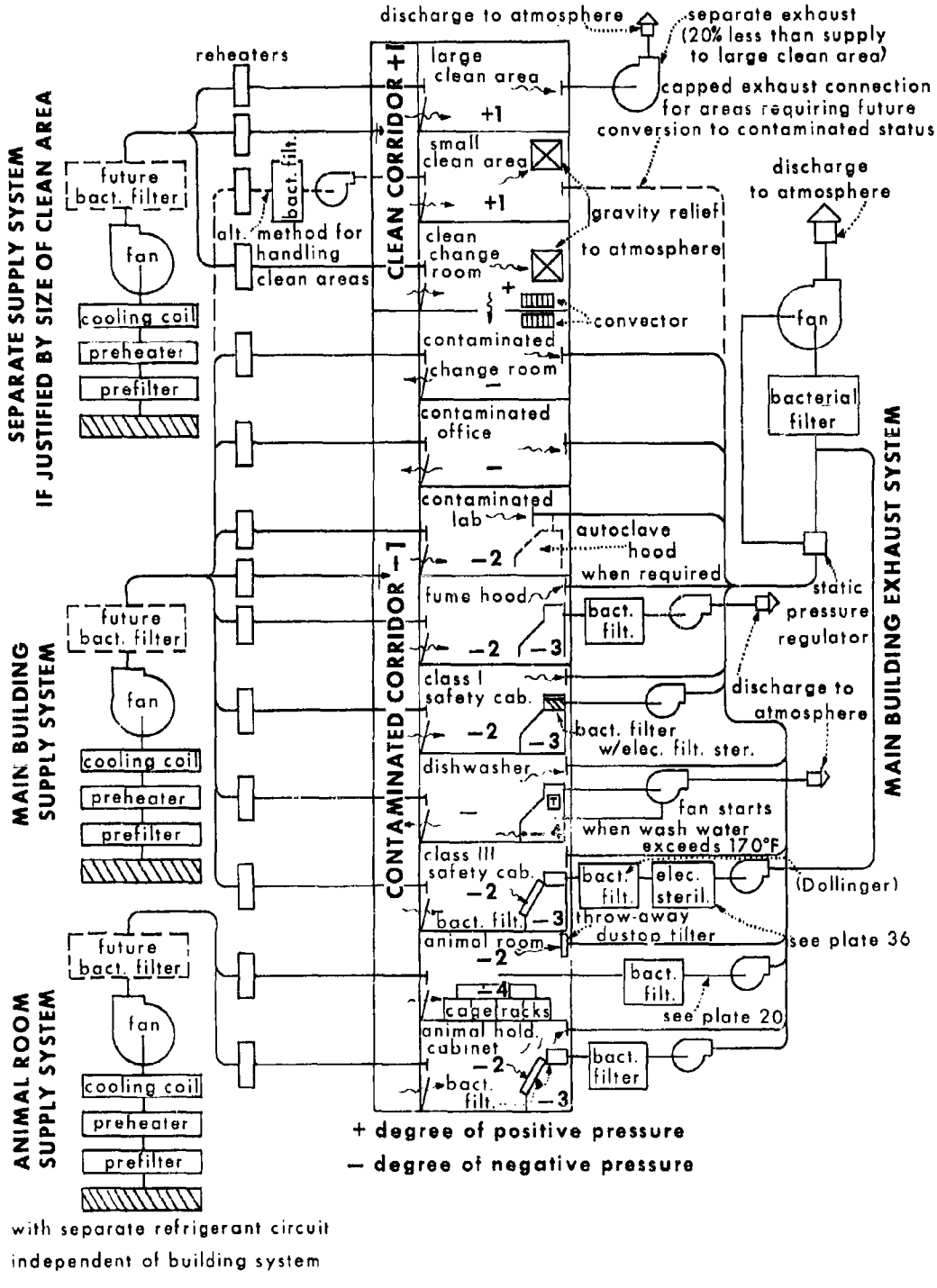

Figure 1. Typical Air Flow Diagram for Contaminated Buildings.

and compressed by pumps that create no oil vapors. Normal ambient temperatures are satisfactory for air supplied to personnel hoods that cover only the head, but air for an impermeable suit should enter the suit at a temperature of 68° to 75°F and at a relative humidity no greater than 40 per cent.

Consumption of electricity in infectious disease units may be high because of the many motors, compressors, and other equipment; therefore, if UV lamps are to be employed, adequate circuits should be provided.

For especially hazardous microbiological operations, in which entire rooms may sometimes be accidently contaminated with a resistant microorganism, the electrical conduits need special attention. It has been found by experience that, with slight changes in air pressure, such contamination will escape from one room to another through an unsealed electrical conduit. Therefore, it is advisable to provide explosion-proof sealing conduit filled with DEL seal or Permagum* in conduit lines. Seals should be provided around all pipes and ducts that extend through floors, walls, or ceilings to prevent escape of microorganisms.

Since a building designed for infectious disease work uses many services, such as compressed air and vacuum, there may be more structural opportunities for transmission of vibration throughout the superstructure. Vibration is particularly annoying in the use of delicate laboratory equipment such as balances. Therefore, it is suggested that particular attention be paid to the cushioning of large motors and pumps and other machinery that may cause vibration. Motors and blowers should be placed outside the laboratory area if possible.

G. WATER SUPPLIES

Drinking water should be available only from a foot-operated drinking fountain, preferably located outside the contaminated laboratories or animal rooms. Potable drinking water in the infectious unit and the general water supply of adjacent areas should be protected from possible contaminated back siphonage by an attic or basement breaktank between the drinking water (general water supply lines) and the water line to the infectious unit. Such a hazardous cross-connection may occur from a rubber hose connected to a water line and terminating in a sink that may accidentally receive contaminated wastes. A mechanical backflow preventor is permissible but less certain than a breaktank in its continued effective operation.

Distilled water for use in the laboratory, media preparation, or dishwashing rooms is often supplied from a central water distilling apparatus and piped to the room. The still should be located in the attic for gravity and should not be installed in the infectious disease laboratory itself.

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* Prestite Engineering Co., St. Louis, Missouri.

H. WASTE DISPOSAL

Unless the hazard is extreme, or normal disposal methods uncertain, no treatment of liquid effluents from the change rooms is necessary. All other liquid or solid waste materials known to be contaminated, or potentially contaminated drainage from laboratory benches or cabinets and hoods, may require treatment at about 200°F for 30 seconds in a blowcase. (This depends upon the nature of experiments and the organisms under study.) If a significant amount of Bacillus anthracis gets into these drains, a temperature of 260°F for 10 minutes is necessary. Infrequently used floor drains should contain a liquid disinfectant in the trap; all drains should be properly trapped and the traps kept full of water. Traps should be deep enough so that differential room air pressure will not cause them to empty by siphonage.

I. ULTRAVIOLET

Germicidal ultraviolet (UV) radiation in the region of 2537Å, as produced from a low-pressure mercury vapor discharge tube, can be used advantageously in the infectious disease laboratory in a variety of ways.

UV air locks and door barriers are desirable in separating areas of significantly different levels of contamination.[13] An air lock is considered to be a small, empty transition room with a door at each end, constructed to create a dead-air space between two areas. Typical air locks should be at least eight feet long and six feet wide with an eight-foot ceiling height. Unshielded UV lamps should be mounted on the ceiling to provide a constant floor intensity of at least 20 microwatts per square centimeter. The lamps should be controlled from a switch outside the air lock.

UV door barriers are constructed by placing UV fixtures in a channel built around a doorway opening in such a way that a narrow band of radiation screens the opening. It is often desirable to place a UV barrier around the doorway of one of the doors of a UV air lock. UV air locks and door barriers are not intended to decontaminate surfaces, clothing, or equipment, but only to treat air that may pass from one area to another when doors are opened.

Placing a suitable number of unshielded UV lamps in the ceiling of laboratory rooms will provide considerable clean-up of infectious and non-infectious "nuisance" microorganisms during nonoperating hours. Lamps should provide a floor intensity of approximately ten microwatts per square centimeter.

The design and testing of UV air locks, door barriers, and ceiling installations has been described elsewhere.[14]

If window-type air conditioning units are used in infectious areas, UV lamps may be installed to decontaminate the recirculated air. Tests indicate UV irradiation will give a 99.98 per cent reduction of air-borne Serratia indica in a recirculating system with an air flow of about 350 cfm.[15] A small-volume (1 to 10 cfm) UV air sterilizer has been described that is useful for eliminating infectious microorganisms in air being discharged from aerated bacterial cultures or from small aerosol chambers.[16] This apparatus consists of four sealed aluminum tubes connected in series, each containing one UV lamp. UV treatment of exhaust air from rooms can substitute for mechanical filtration, but it must be realized that such treatment rarely eliminates all microbial forms.

References to other uses of UV in infectious laboratories are noted later in this report.

III. BASIC SAFETY EQUIPMENT FOR INFECTIOUS DISEASE UNITS

At least a part of the equipment and apparatus needed should be described because they, along with some special techniques, are essential for the maintenance of safe working conditions in the infectious disease unit. It is evident, however, that the need for certain equipment will be determined by the infectious organism in use and the type of operation being conducted. Experiments with aerosols of infectious microorganisms and lyophilizing, drying, mixing, and grinding procedures, for example, are usually hazardous.

A. VENTILATED CABINETS

Numerous publications on the frequency, causes, and elimination of laboratory-acquired infections have led to the conclusion that the source of infection is generally within a few inches of the laboratory worker's face, and that enclosing and ventilating the work area is the most important factor in eliminating laboratory infections. A ventilated bacteriological cabinet provides suitable table-top area for the performance of bacteriological operations and has a pane of glass between the work and the worker's face. Escape of microorganisms is prevented by an inward flow of air or a reduced air pressure within the cabinet.

A variety of ventilated bacteriological cabinets are available commercially,[8,17]* or can be fabricated from plywood or sheet metal. Portable cabinets of flexible plastic sheeting can be used for special operations.[18] Modular cabinet systems, made of stainless steel joined together by bolts or adhesive compounds, are recommended for highly hazardous operations. Autoclaves, disinfectant dunk baths, refrigerators, incubators, deep freezes, balances, and sinks can be attached to these cabinets. Each cabinet or system is provided with an air filter[19] and an exhaust blower that isolates each cabinet or system. Cabinets may be used with an open panel, with the blower creating an inward air flow of approximately 50 linear feet per minute, or closed, with all work done through attached arm-length rubber gloves,** during which time the blower is expected to maintain a reduced pressure of one half to one inch of water within the cabinet. Cabinets may also be supplied with vacuum, air, gas, electricity, water, drains, UV and fluorescent lighting.

Respiratory challenge of animals with infectious organisms may be accomplished by generating an aerosol in equipment, such as the Henderson apparatus,[20,21] mounted in a safety cabinet. After exposure to the aerosol, animals are transferred to the animal holding room through an air lock that extends through the laboratory wall into the animal room. In the

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* S. Blickman, Inc., Weehawken, New Jersey and Kewaunee Manufacturing Co., Adrian, Michigan.

** Charleston Rubber Co., Charleston, South Carolina.

animal room, the animals are placed in ventilated cages[8] on UV cage racks.[22] Animal caretakers should wear a respiratory protective device as well as goggles to protect the eyes from UV.

The safety cabinet is the most important single piece of equipment in preventing laboratory infections. It cannot, however, substitute for good training and good laboratory housekeeping; it combines with these to provide the maximum in safe operating conditions.

B. CENTRIFUGE EQUIPMENT

Aerosols created by breakage of glass tubes during centrifuging or by loss of the tube stoppers constitute a hazard to operating personnel.[23] Safety cups and heads* should be used. Tubes of various sizes are placed in adapters, which fit into safety trunnion cups or angle head safety cups, and biologically tight covers are put in place. After centrifuging, the capped cups are returned to the safety cabinet for opening. The centrifuge and the cabinet should be located in the same room. Table-top centrifuges for which no safety cups are available should be placed in the safety cabinet during operation.

C. PIPETTING DEVICES

One of the most common causes of laboratory infection is the direct aspiration of pathogenic materials into the mouth while pipetting. Oral pipetting of pathogenic cultures should not be allowed, and suitable pipetting devices should be supplied. A variety of devices are available,[24]** some of which operate from the laboratory vacuum line. Recommended methods for the use and handling of pipettes should be followed.[25]

D. DEVICES FOR DECONTAMINATION AND STERILIZATION

1. Autoclaves

The use of a double-door autoclave between the laboratory or animal room and the "clean" preparation area is recommended. This allows a positive system to be established for the flow of contaminated discard materials. Autoclaves should be equipped with pressure-activated door locks. Automatic interlocks may be used to prevent the door on the "clean" side from being opened until a sterilization cycle has been completed.

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* International Equipment Co., Boston, Massachusetts.

** Propipettes, Schaar & Co., Chicago, Illinois; Clinac Pipetter, Tenso-Lab Inc., Irvington-On-Hudson, New York.

2. Ethylene Oxide Chambers

When a delicate instrument such as a pH meter or analytical balance becomes contaminated with infectious materials, adequate decontamination is usually impossible unless a sterilizing gas such as ethylene oxide is used.[10,26] It is suggested, therefore, that at least one autoclave in each unit be equipped for gaseous sterilization. Carboxide gas,[a] a mixture of ethylene oxide and carbon dioxide gases, may be used. This requires that the autoclave be connected to the laboratory vacuum and to tanks of carboxide. To operate the autoclave, a vacuum of about 16 inches of mercury is drawn on the chamber and carboxide gas injected to a positive pressure of 20 psig. Exposure time is usually 12 hours or overnight. Because of its toxic and flammable characteristics, pure ethylene oxide should not be used as a gaseous disinfectant.

A more convenient procedure is made possible by the use of low-pressure disposable cans containing a mixture of ethylene oxide and Freon.[b] These cans eliminate both the hazards involved in the handling of high-pressure gases and the need for buying or renting cylinders.

3. Ultraviolet Paper Sterilizer

A UV pass-through chamber for disinfecting single sheets of paper may be installed in the wall separating the "clean" from the "contaminated" area.[27] This apparatus rolls sheets of paper slowly between UV lamps that provide a radiation dose sufficient to inactivate 99.97 per cent of contaminating bacterial spores.

4. Vaporizers

Disinfectant vaporizers[c] may be used to decontaminate the air and surfaces in enclosed areas such as rooms or ventilated cabinets.[10] They may also be used to decontaminate bacterial filters or large items of equipment such as refrigerators, incubators, or deep freeze units.

In decontaminating enclosed areas when there is no ventilating equipment in operation, one milliliter of 37 per cent formaldehyde solution should be vaporized for each cubic foot of air space and allowed to act for six to eight hours. The initial relative humidity should be at least 80 per cent and the temperature at least 70°F. In ventilated areas, air flow should be reduced as much as possible, and additional formaldehyde vaporized to treat the added air volume.

Filter media may be decontaminated in place with air moving through them by vaporizing one milliliter of 37 per cent solution per cubic foot of air per minute for 30 minutes.

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a. Carbide & Carbon Chemicals Corp., New York.
b. Pennsylvania Engineering Co., Philadelphia, Pennsylvania.
c. Hydromist Vaporizer, Model H, Arnold Labs., 2507 S. Main Street, Los Angeles 7, California.
Challenger Vaporizer, Model 5100, Z&W Machine Products, Cleveland, Ohio.

When the building air balance is maintained, and when the supply system uses 100 per cent make-up air, little trouble should be experienced with seepage of formaldehyde fumes to other areas. In recirculating air systems, and in construction that obviously is not air-tight, it may be necessary to seal off areas to be decontaminated by closing air supply and exhaust ducts and using masking tape to close other cracks and crevices.

Beta-propiolactone, dispersed in the same manner in concentrations of 300 milligrams per cubic foot of space, is an effective air and surface decontaminant; however, it has been found to be less effective than formaldehyde in decontaminating filters.

E. ANIMAL ROOM EQUIPMENT

The frequent association of laboratory infections with animal handling warrants special attention to the procedures and equipment used for holding experimentally infected animals. There is a surprising variation in the extent to which various bacteria, viruses, and rickettsiae will cause cross-infection of animals, thereby imperiling the validity of the experiment as well as providing a potential hazard to the animal handler. The need for special cages and cage racks will depend upon the organism under study. This matter is now under systematic study in our laboratory and some results have been reported.[28-30] There is a great deal of practical knowledge on this subject among experienced investigators, but very little has been published, except by casual mention in the course of reporting other results.[31-33] The following equipment is recommended where applicable.

1. Ultraviolet Cage Racks

If the use of experimental animals does not include challenge by the intranasal or respiratory routes, animals may be placed in solid-sided metal cages with screen wire tops, and the cages kept on cage racks equipped with UV lamps. Lamps used with reflectors are placed to provide a radiation barrier across the top of each cage, thereby preventing the outward escape of most air-borne organisms.[22]

2. Ventilated Animal Cages

Animals challenged with infectious organisms by the respiratory route should be held in ventilated cages until they no longer shed significant numbers of organisms from their fur or in their excretions. In organisms studied to date, this time is about three to six days; but it will need to be determined for each organism. Several types of ventilated cages have been described elsewhere.[8,34,35]

3. Respiratory Protection

In the absence of ventilated cages, and sometimes even in their presence, it is advisable for animal workers in infectious holding rooms to use respiratory protection. We have found the use of a ventilated personnel hood* to be satisfactory, because it provides good respiratory protection and skin and eye protection from UV (2537Å) radiation. Hospital gauze masks have limited value because their filtration efficiency is low for particles less than 5.0 microns in diameter.[36] Some types of commercial respirators offer adequate protection, but in this instance, if UV cage racks are used, safety goggles or shields must be worn to prevent UV eye burns. Standard military-type gas masks are also effective.

* Snyder Manufacturing Co., New Philadelphia, Ohio.

IV. TYPICAL DESIGNS FOR A SMALL INFECTIOUS DISEASE UNIT

Typical layout designs, illustrating the principles previously discussed, are shown in Figures 2, 3, and 4. It is intended that these designs be flexible to allow convenient modification.

Plan I (Figure 2) includes a laboratory for the challenge of animals by exposure to infectious aerosols. Plan II (Figure 3) utilizes rooms on both sides of a central corridor when the area is not at the end of a wing and when the corridor must be used for access to other parts of the building. When the infectious disease unit is to be confined to one side of a corridor, Plan III (Figure 4) is suggested.

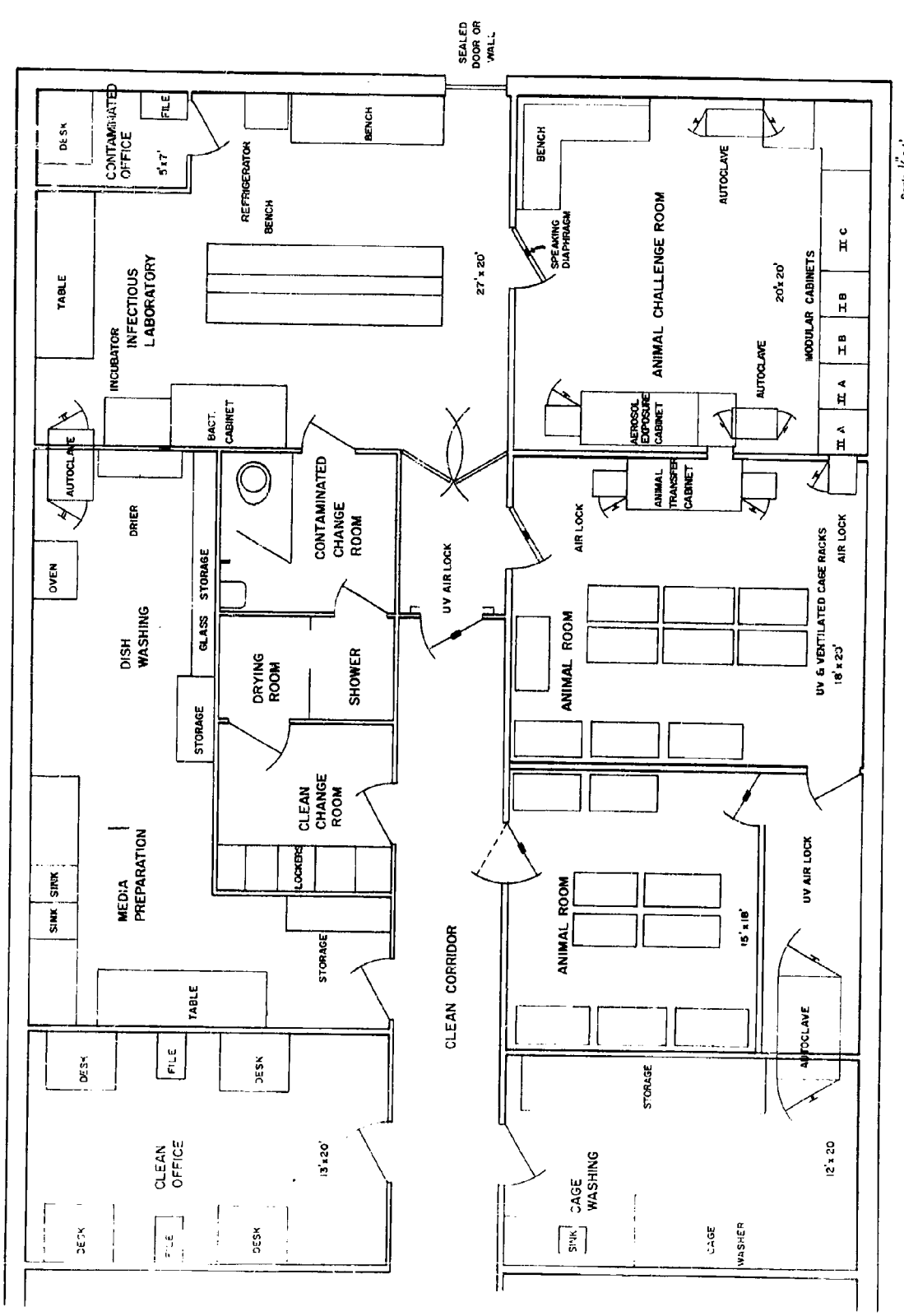

Figure 2. Infectious Disease Laboratory Layout, Plan I.

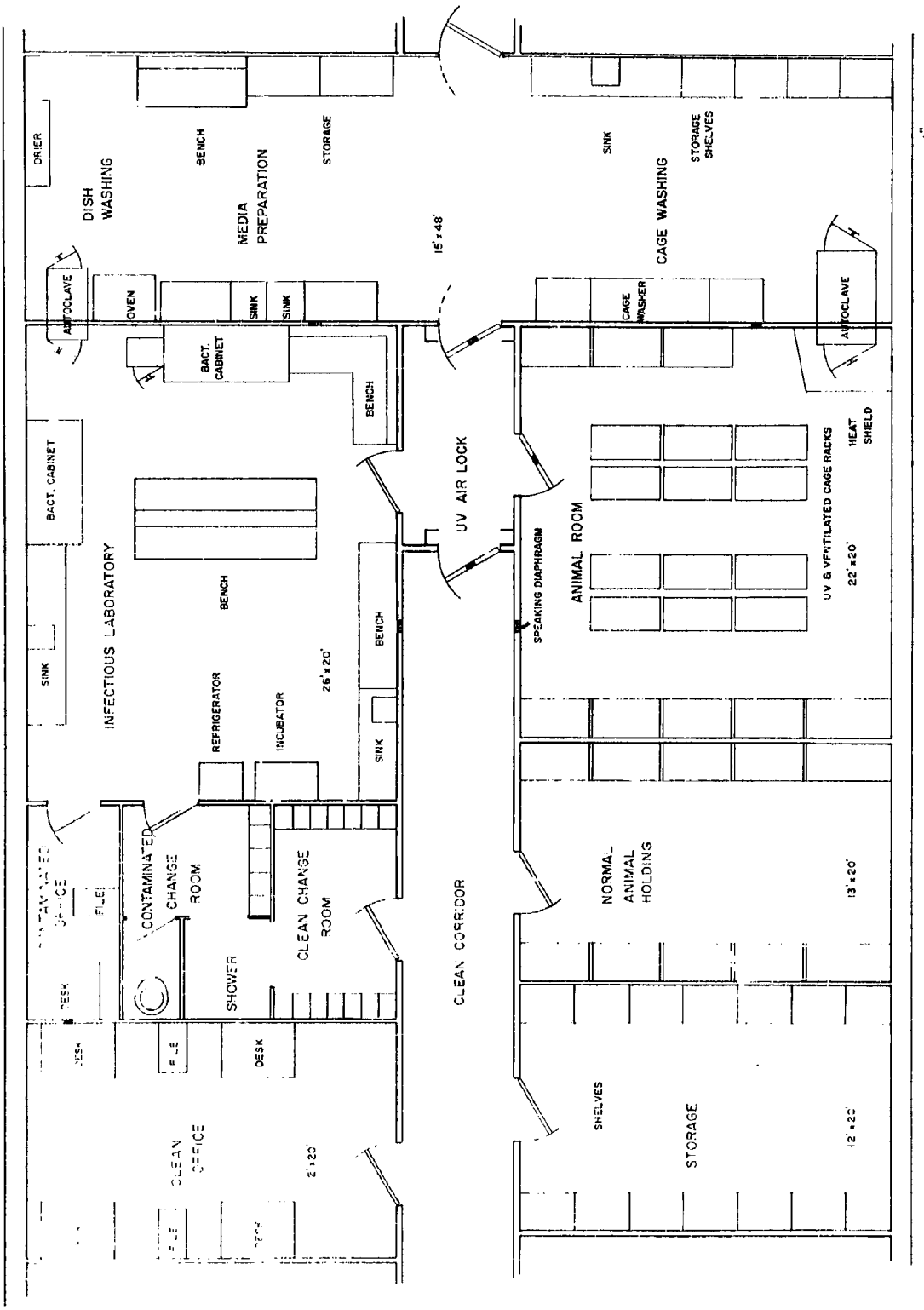

Figure 3. Infectious Disease Laboratory Layout, Plan II.

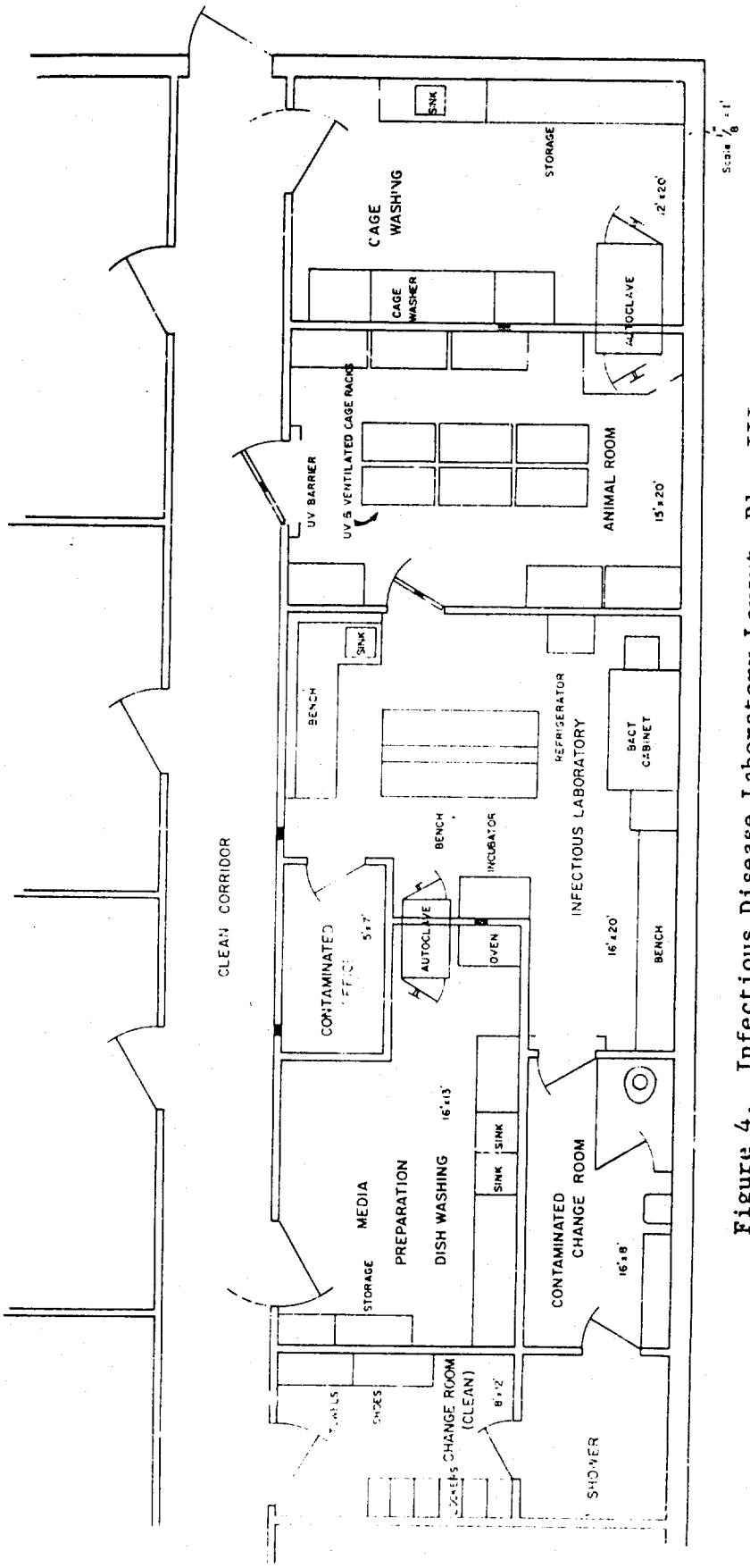

Figure 4. Infectious Disease Laboratory Layout, Plan III.

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